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LAUNCH VEHICLE

TRAJECTORY CERTIFICATION REVIEW

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PURPOSE OF REVIEW

- TO DESCRIBE THE PROCESS AND PRESENT THE TECHNICAL ANALYSES UNDERTAKEN TO VERIFY THE MCDONNELL DOUGLAS AEROSPSACE (MDA) INJECTION CONDITIONS AND TO GAIN CONFIDENCE IN THE MDA TRAJECTORY SIMULATIONS INCLUDING:
  - VERIFICATION THAT THE MDA INJECTION CONDITIONS ARE CONSISTENT WITH THE TARGET SETS SPECIFIED IN THE FINAL TARGET SPECIFICATION
  - VERIFICATION THAT THE DESIRED B-PLANE AIMPOINTS AT MARS ARE ACHIEVED WITHIN ACCEPTABLE BOUNDS
  - VERIFICATION THAT THE “NON-BURN” ATTITUDES AND OTHER SPECIAL MISSION REQUIREMENTS SPECIFIED IN THE FINAL TARGET SPECIFIATION HAVE BEEN SUCCESSFULLY INCORPORATED INTO THE DELTA FLIGHT PROFILE
  - PRESENT THE INDEPENDENT VERIFICATION AND VALIDATION ACTIVITIES OF OUTSIDE AGENCIES
- TO PROVIDE A FORUM FOR A CRITICAL REVIEW OF THE TRAJECTORY CERTIFICATION PROCESS AND TO IDENTIFY ANY PROBLEMS OR AREAS IN WHICH FURTHER VERIFICATION WORK IS NECESSARY

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AGENDA (1 OF 2)

TOPIC	PRESENTER	TIME
LAUNCH VEHICLE TRAJECTORY	D. JOHNSTON	9:00
CERTIFICATION DATA		
• MDA DETAILED TEST OBJECTIVES (DTO) REPORT => LAUNCH PROFILE DATA		
LAUNCH OVERVIEW	D. JOHNSTON	9:05
• LAUNCH PERIOD / LAUNCH WINDOW		
• DELTA II 7925A FLIGHT PROFILE / TIMELINE		
ACHIEVED TARGET CONDITIONS	D. CASEY	9:20
• TARGET VERIFICATION APPROACH		
– TRAJECTORY INTEGRATION: DPTRAJ		
– C3, DLA, RLA <--> STATE VECTOR COMPONENTS		
• NEAR EARTH TARGET SETS ACHIEVED		
• B-PLANE TARGET SETS ACHIEVED		
• LAUNCH WINDOW - INTEGER SECOND IMPACT		

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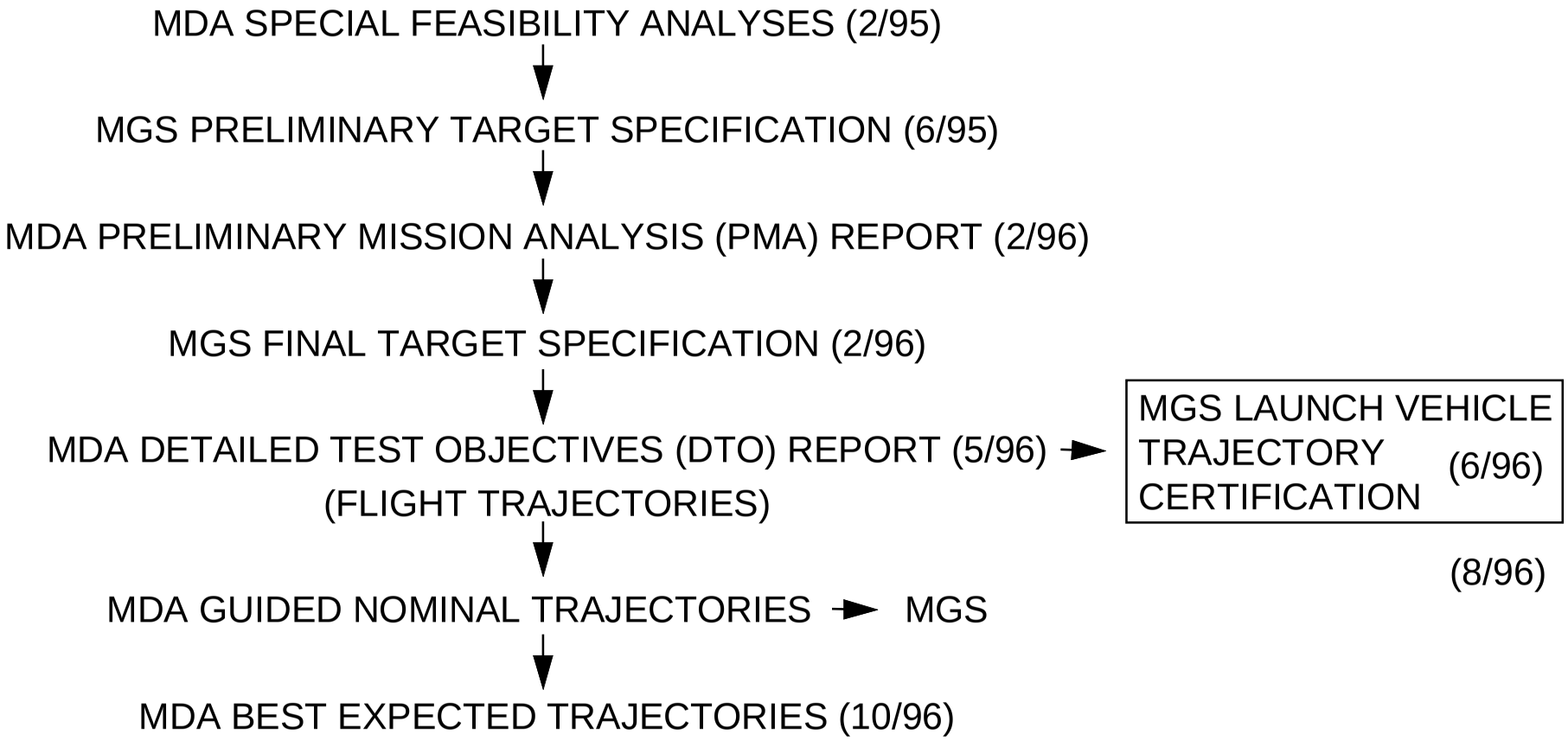
AGENDA (2 OF 2)

TOPIC	PRESENTER	TIME
"NON-BURN" ATTITUDE REQUIREMENTS	D. CASEY	9:40
• ATTITUDE VERIFICATION APPROACH		
– DELTA II ATTITUDE TIMELINE		
• SUN ANGLE CONSTRAINTS		
• THERMAL ROLL		
• SPACECRAFT SEPARATION ATTITUDE		
• COLLISION AVOIDANCE		
SPECIAL MISSION REQUIREMENTS	D. JOHNSTON	10:00
INDEPENDENT / EXTERNAL CHECKS	D. CASEY	10:05
CONCLUSIONS / OPEN ITEMS	D. JOHNSTON	10:15

LAUNCH VEHICLE INTEGRATION
TRAJECTORY DESIGN CYCLES

***TRAJECTORY DATA FLOW ***



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LAUNCH VEHICLE TRAJECTORY CERTIFICATION DATA

- FINAL TARGET SPECIFICATION DOCUMENT WAS DELIVERED TO MCDONNELL DOUGLAS ON 2/15/96
  - CONTAINS TARGETS (C3, DLA, AND RLA) FOR 21 LAUNCH DAYS (32 LAUNCH OPPORTUNITIES)
  - CONTAINS SPECIAL MISSION AND “NON-BURN” ATTITUDE REQUIREMENTS

- REQUIREMENT FOR CERTIFICATION TRAJECTORY DATA IS LEVIED IN THE MGS FINAL TARGET SPECIFICATION DOCUMENT
  - SECTION 5.2 TARGETING CERTIFICATION TRAJECTORIES
  - SECTION 5.1 LAUNCH PROFILE DATA

- MCDONNELL DOUGLAS AEROSPACE (MDA) DETAILED TEST OBJECTIVES (DTO) REPORT
  - RECEIVED (UNSIGNED) PRELIMINARY VERSION - 5/22/96
    - MDA DELIVERED A SET OF 32 TARGETED TRAJECTORIES ELECTRONICALLY (OR CERTIFICATION TRAJECTORIES) TO JPL IN LATE MAY 1996 (I.E. LAUNCH PROFILE DATA)
  - RECEIVED FINAL (SIGNATURE) VERSION WITHOUT ATTACHMENT - 7/29/96
  - RECEIVED FINAL (SIGNATURE) VERSION WITH ATTACHMENT - 8/6/96

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LAUNCH OVERVIEW
DELTA II 7925A LAUNCH VEHICLE

- DELTA II 7925A LAUNCH VEHICLE CHARACTERISTICS
  - FIRST STAGE LIMITED TO A FIXED (SINGLE) LAUNCH AZIMUTH
    => “LAUNCH ON TIME” (INSTANTANEOUS LAUNCH WINDOWS)
  - SECOND STAGE HAS MULTIPLE RESTART CAPABILITY (MGS UTILIZES ONE RESTART)
  - SECOND STAGE HAS GUIDANCE CAPABILITY - ORIENTS THIRD STAGE FOR INJECTION BURN
  - THIRD STAGE (SOLID) SPIN STABILIZED FOR INJECTION (60 RPM)
  - YO-YO DESPIN SYSTEM => 0 RPM
  - LAUNCH VEHICLE TRAJECTORY - UTILIZES AN EARTH RELATIVE FLIGHT PROGRAM
  - DELTA II MISSION CONSTANTS / LAUNCH VEHICLE GUIDANCE
    - PARKING ORBIT INSERTION (SECO-1) - POSITION AND VELOCITY MATCH
    - RESTART BURN (SECO-2) - VELOCITY MATCH
    - USAGE OF GUIDANCE RESETS ON A GIVEN AZIMUTH
  - MGS WILL BE THE FOURTH LAUNCH OF THE DELTA II 7925 AUV

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LAUNCH OVERVIEW
LAUNCH PERIOD DESIGN FACTORS

- MGS SPACECRAFT INJECTED MASS: 1060.0 KG
  - MGS FINAL TARGET SPECIFICATION USED 1055.0 KG
- DELTA STAGE II PROBABILITY OF COMMAND SHUTDOWN (PCS)
  - LAUNCH VEHICLE PERFORMANCE MEASURE
  - MINIMUM ACCEPTABLE DELTA STAGE II PCS = 95% (1 IN 20 CHANCE OF NOT COMPLETNG THE SECOND STAGE RESTART BURN)
- IMPORTANT LAUNCH PERIOD NOTES
  - MGS WILL EMPLOY A LAUNCH STRATEGY THAT USES TWO INSTANTANEOUS LAUNCH OPPORTUNITIES DURING THE FIRST TEN (10) DAYS OF THE LAUNCH PERIOD (LAUNCH PROBABILITY IS A MAJOR PROJECT CONCERN)
  - ARIA COVERAGE REQUIREMENT (OPEN ISSUE)
    - NASA HQ REQUIREMENTS TO MONITOR ALL LAUNCH VEHICLE POWERED FLIGHT AND SEPARATION EVENTS
    - DEPOLYABLE GROUND STATION USAGE

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LAUNCH OVERVIEW
LAUNCH PERIOD

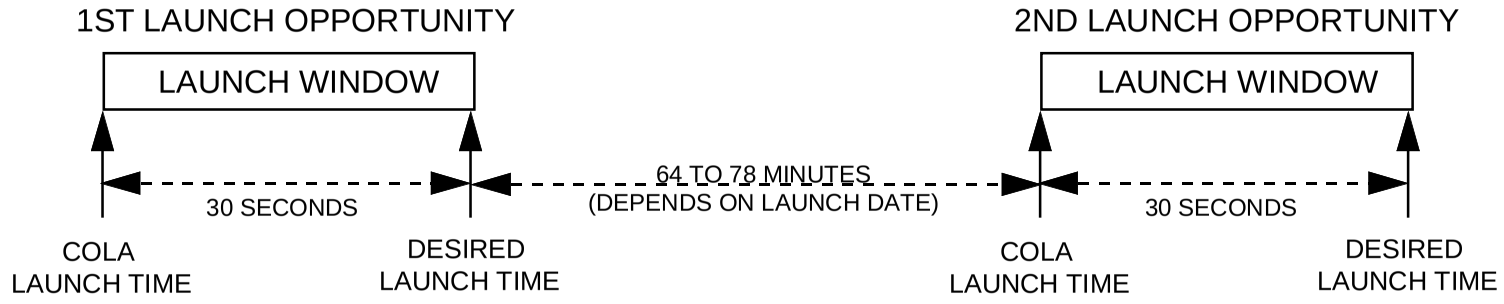
- LAUNCH PERIOD: NOV 6 THROUGH NOV 25, 1996
  - NOV 6 THROUGH NOV 15, 1996
    - TWO OPPORTUNITIES PER DAY
      - BOTH SHORT COAST
      - SATISFIES LAUNCH OPERATIONS CONSTRAINTS*
    - LAUNCH AZIMUTHS = 93.0 DEG AND 99.89 DEG
    - PARKING ORBIT INCLINATIONS = 28.470 DEG AND 29.818 DEG
    - DELTA STAGE II PCS (S/C MASS = 1060.0 KG) = 98.6% AND 97.9%
  - NOV 16 THROUGH NOV 25, 1996
    - ONE OPPORTUNITY PER DAY
      - SHORT COAST
    - LAUNCH AZIMUTH = 110.0 DEG
    - PARKING ORBIT INCLINATION = 36.5 DEG (DOG-LEG TRAJECTORY)
    - DELTA STAGE II PCS (S/C MASS = 1060.0 KG) = 97.3%

*LAUNCH OPERATIONS CONSTRAINTS

- TWO-A-DAY CONSTRAINT: 64 MIN $\leq$ LIFTOFF ΔT $\leq$ 78 MIN
  - 64 MIN - TIME TO RELOAD DELTA GUIDANCE PARAMETERS (LAUNCH AZIMUTH CHANGE)
  - 78 MIN - TIME TO COMMENCE LOX UNLOADING BEFORE DELTA FIRST STAGE PROPELLANT LINES BEGIN TO FREEZE

LAUNCH OVERVIEW
LAUNCH WINDOW

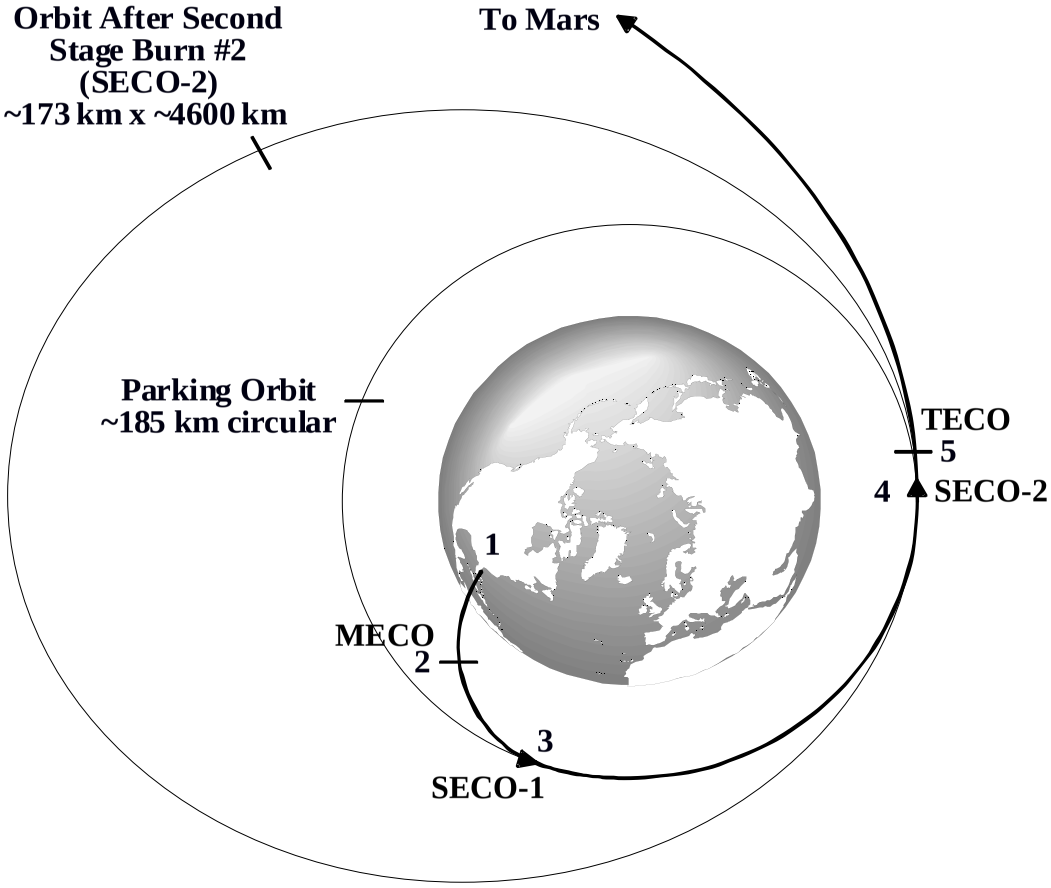
- LAUNCH WINDOWS (INSTANTANEOUS)
  - THE DESIRED (PLANAR) LAUNCH TIME FOR EACH LAUNCH OPPORTUNITY IS BASED ON A DELTA FLIGHT PROFILE THAT ACHIEVES THE TARGETING CONDITIONS SPECIFIED IN THE MGS FINAL TARGET SPECIFICATION DOCUMENT -- THIS DESIRED (PLANAR) LAUNCH TIME WILL BE SPECIFIED TO THE NEAREST INTEGER SECOND (FINAL TS SEC 3.3)
  - AN OPPORTUNITY TO LAUNCH WILL EXIST 30 SECONDS PRIOR TO THE DESIRED LIFTOFF TIME AND WILL BE USED ONLY IN THE EVENT THE EASTERN TEST RANGE (ETR) ISSUES A COLLISION AVOIDANCE (COLA) WARNING (ACCOMODATES ETR COLA REQUIREMENT)
  - THE LAUNCH WINDOW FOR EACH LAUNCH OPPORTUNITY WILL OPEN 30 SECONDS BEFORE AND CLOSE AT THE DESIRED LAUNCH TIME (RANGE)



LAUNCH OVERVIEW

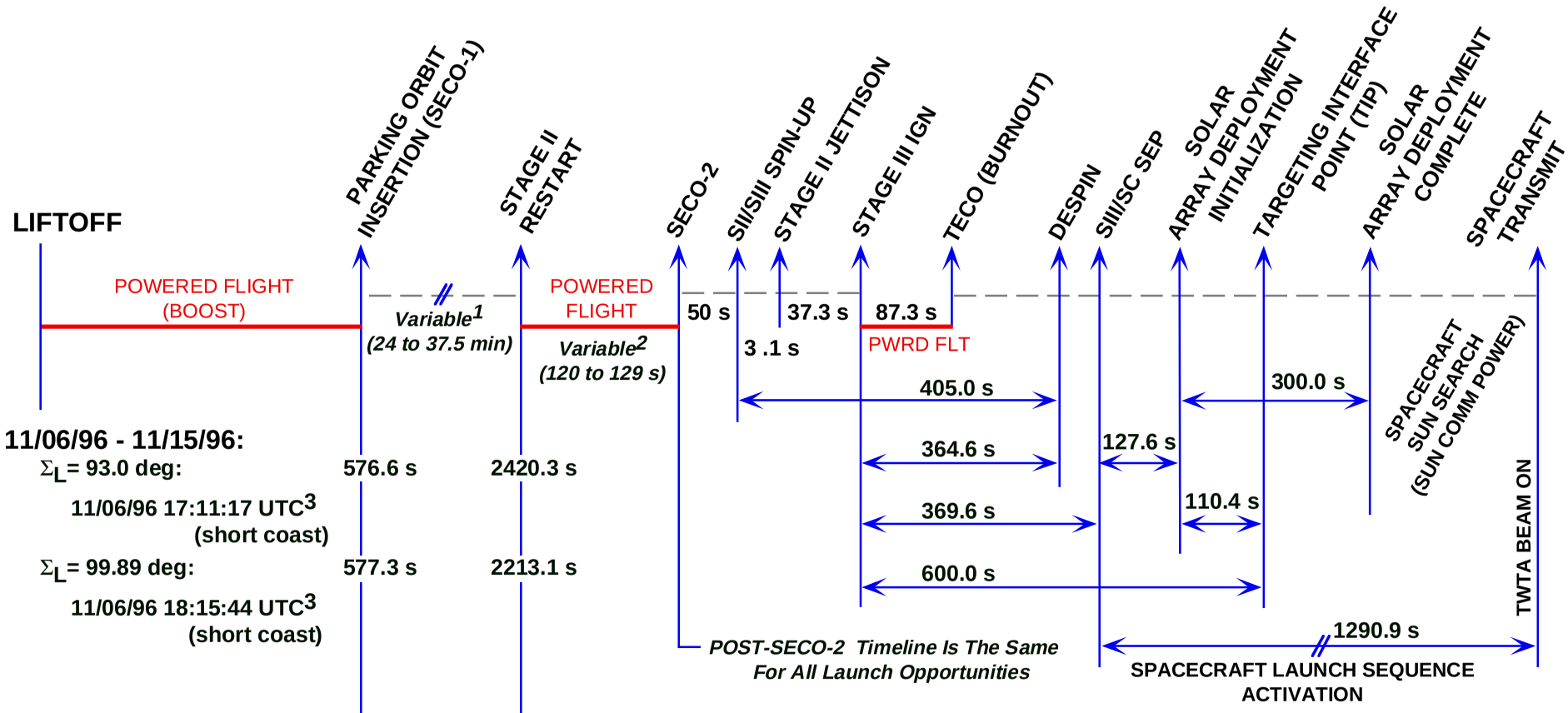
DELTA II 7925A FLIGHT PROFILE OVERVIEW

1. Liftoff (time varies each launch day)
2. MECO
   1st Stage main engine cut-off
   2nd Stage ignition
   (same time for given launch azimuth)
3. SECO-1
   2nd Stage cut-off #1
   (same time for given launch azimuth)
4. 2nd Stage Restart / SECO-2
   ~Two minute burn raises apogee
   (Burn start time, duration, and attitude varies each launch day => depends on required C3)
5. 3rd Stage Ignition / TECO
   87.3 s burn puts MGS spacecraft on hyperbolic escape trajectory (burn duration same for all launch days with burn start always 90.4 s after SECO-2)



LAUNCH OVERVIEW

DELTA II 7925A FLIGHT PROFILE TIMELINE



[1] *Variable- Parking Orbit to Stage II Restart Burn Coast Time Varies For Each Launch Opportunity*

[2] *Variable - Stage II Restart Burn Duration and Attitude Vary For Each Launch Opportunity*

[3] *An opportunity to launch will exist 30 seconds prior to the nominal liftoff time and will only be used in the event the Eastern Test Range (ETR) issues a collision avoidance (COLA) warning*

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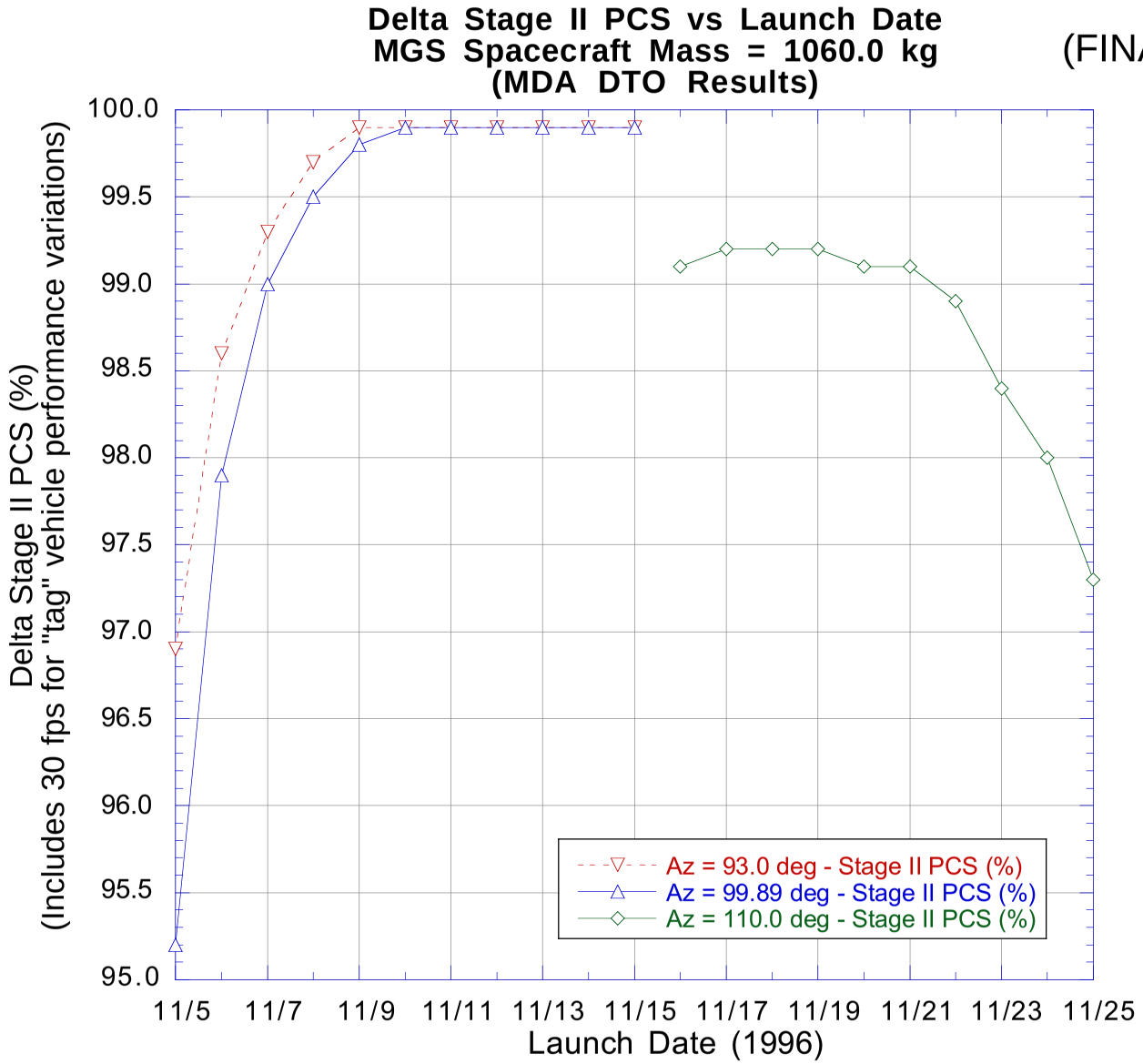
SPECIAL MISSION REQUIREMENTS

(FINAL TS SEC 3.4)



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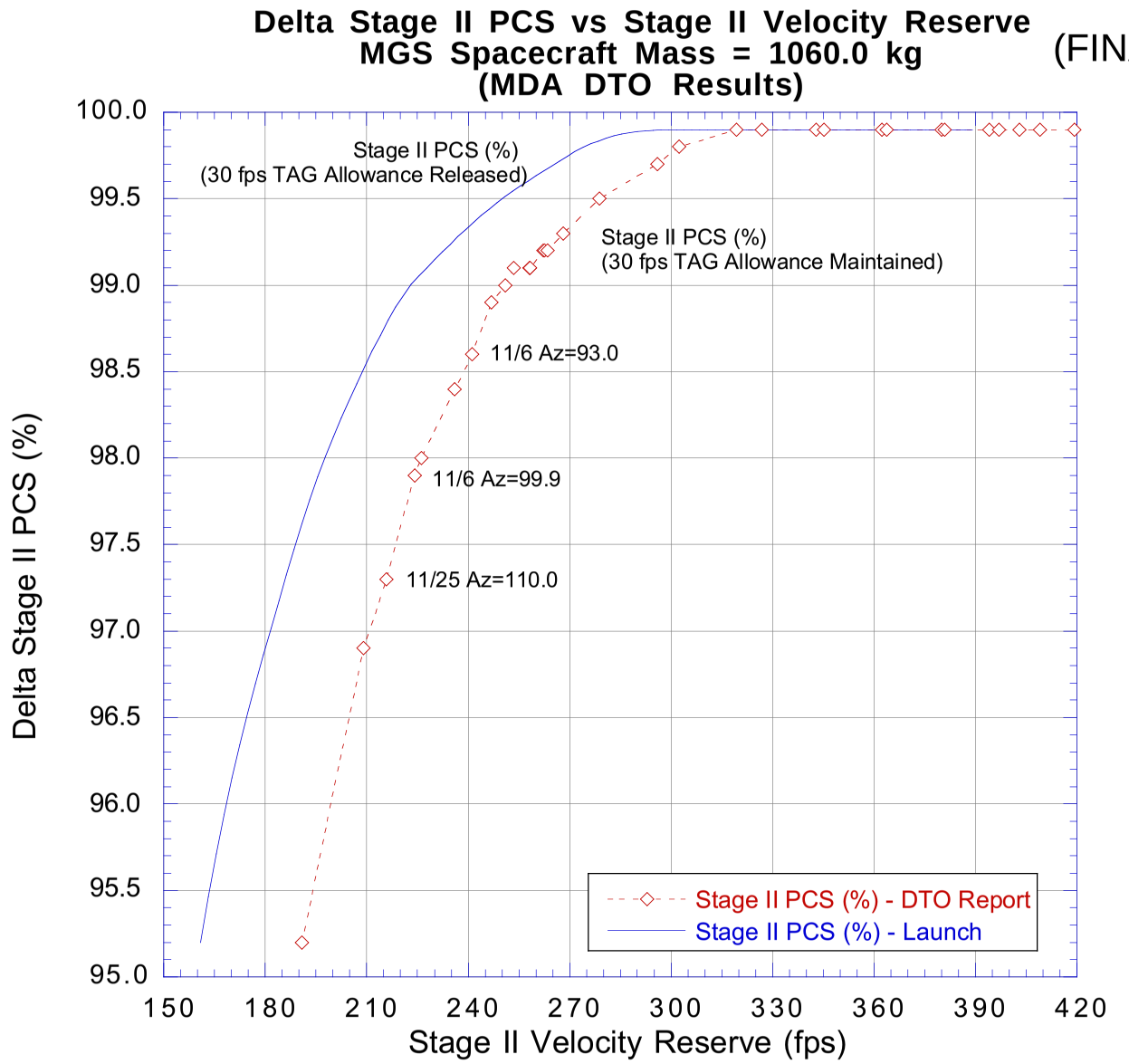
SPECIAL MISSION REQUIREMENTS

(FINAL TS SEC 3.4)



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SPECIAL MISSION REQUIREMENTS

- DELTA THIRD STAGE SPIN RATE (FINAL TS SEC 3.11)
  - FINAL TS: 60 RPM DTO REPORT: 59 RPM

    INCORPORATED INTO THE MDA DELTA II MGS MISSION SPEC DOCUMENT (SEC 1.5): "APPROXIMATELY 60 ± 7 RPM"

- NUTATION TIME CONSTANT (FINAL TS SEC 3.12)
  - AT THIRD STAGE IGNITION: 131.0 S (WORST CASE)
  - AT THIRD STAGE BURNOUT: 55.0 S (WORST CASE)

  ASSUMES SPIN RATE OF 60 RPM

  INCORPORATED INTO THE MDA DELTA II MGS MISSION SPEC DOCUMENT (SEC 1.5)

- TARGETING CONSTANTS (FINAL TS SEC 3.13)
  - GRAVITATIONAL CONSTANTS USED FOR TRAJECTORY MODELING BASED ON A MDA GRAVITY FIELD (WGS 84 PARAMETERS COUPLED WITH STS (JSC-08934) HARMONIC TERMS)

    (ACCEPTABLE BUT NOT DESIREABLE)

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SPECIAL MISSION REQUIREMENTS

- TARGETING ERROR REQUIREMENT (FINAL TS SEC 3.14)
  - TARGET PARAMETERS (C3, DLA, AND RLA) ACHIEVED EXACTLY FOR MILLISECOND LAUNCH TIMES => INTEGER SECOND LAUNCH WINDOWS (ROUNDING)
    - ΔV PENALTY << 2.5 M/S

- FREE MOLECULAR HEATING RATE (FINAL TS SEC 3.15)
  - FINAL TS: 1135.0 W/M2 (0.1 BTU/FT2-S)
  - DTO REPORT: 1135.0 W/M2 (0.1 BTU/FT2-S)

    INCORPORATED INTO THE MDA DELTA II MGS MISSION SPEC DOCUMENT (SEC 2.3)

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CONCLUSIONS (1 OF 2)

- NO SIGNIFICANT CHANGES FROM THE MDA PMA REPORT TO THE MDA DTO REPORT (I.E. LAUNCH AZIMUTHS, PARKING ORBIT INCLINATIONS, ETC.)

- DELTA II FLIGHT PROFILES (POST-SECO 1) SIMULATED BY JPL FOR THE FINAL TARGET SPECIFICATION PRODUCTION WERE A GOOD REPRESENTATION OF THE MDA PRODUCED DTO TRAJECTORIES

- VERIFIED THAT THE MDA INJECTION CONDITIONS ARE CONSISTENT WITH THE TARGET SETS SPECIFIED IN THE FINAL TARGET SPECIFICATION

- VERIFIED THAT THE DESIRED B-PLANE AIMPOINTS AT MARS ARE ACHIEVED WITHIN ACCEPTABLE BOUNDS

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CONCLUSIONS (2 OF 2)

- VERIFIED THAT THE “NON-BURN” ATTITUDES AND OTHER SPECIAL MISSION REQUIREMENTS SPECIFIED IN THE FINAL TARGET SPECIFIATION HAVE BEEN SUCCESSFULLY INCORPORATED INTO THE DELTA FLIGHT PROFILE

- NASA-LERC INDEPENDENT REVIEW ACTIVITIES ARE IN GOOD AGREEMENT WITH JPL TARGET SPECIFICATION PRODUCTS

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LAUNCH VEHICLE MISSION DESIGN - OPEN ITEMS

- LAUNCH VEHICLE CONTRACTOR HAS INDICATED THAT AS MUCH AS AN ADDITIONAL 6.0 KG OF INJECTED MASS PERFORMANCE MAY BE AVAILABLE TO THE PROJECT DUE TO PRELIMINARY THIRD STAGE TAG VALUES
  - AN ASSESSMENT OF THE USE OF THIS CAPABILITY IS IN PROGRESS - MISSION ΔV IMPACTS UNDER REVIEW
  - DOES NOT ALTER THE PCS VALUES

- CONCERNS HAVE ARISEN OVER THE OXIDIZER TANK FILL LEVEL AND ITS RELATIONSHIP TO THE NUTATION TIME CONSTANT DURING THE DELTA THIRD STAGE INJECTION BURN
  - MISSION ΔV IMPACTS UNDER REVIEW

=> SPACECRAFT BALLAST/PROPELLANT LOADING FINAL DECISION MEETING SCHEDULED FOR 9/13/96